assay. They were dried at room temperature, granulated and sealed in amber bottles until assayed. Ten individual plant selections were made and assayed as follows:

No.		Assay percentages	No.		Assay percentages
10	B-1317	0.820	15	B-1322	0.600
11	B-1318	0.710	16	B-1323	0.516
12	B-1319	0.550	17	B-1324	0.616
13	B-1320	0.870	18	B-1325	0.682
14	B-1321	0.664	19	B-1326	0.604
				Average,	0.643

At the same time a mixed sample for assay was taken from the entire plot. This sample consisted of a mixture of leaves and stems or, speaking more correctly, of the entire herbaceous portion of the plants. This sample gave a yield of 0.30 per cent of alkaloids. A portion of this sample was separated into leaves and stems. These parts assayed 0.39 per cent and 0.059 per cent, respectively. Another sample taken from a restricted area of the plot and consisting of leaves only assayed 0.688 per cent. A mixed sample of the roots from this same area assayed 0.43 per cent. It has already been stated that the seeds with which the experimental plot was planted were obtained from a shipment of commercial belladonna leaf. It is interesting to note that this shipment of drug assayed 0.62 per cent.

The principal object of the experiment was to locate individual plants containing high percentages of alkaloids. It was thought that individual belladonna plants growing upon a uniform soil and under the same environmental conditions would show a marked variation in percentage of alkaloids. The variation as noted in this comparatively small number of plants is from 0.516 per cent to 0.87 per cent. The minimum and maximum percentages have evidently not been located with these ten individuals but they furnish abundant material for further study. The inbred seeds from these plants of known yield have been planted. These resulting groups of plants, grown from pedigree seeds, will be further studied for average yields and for individual variations in the percentage of alkaloids. The behavior of these selected plants under the method described will determine the possibility of developing strains which will give a uniformly high yield of alkaloids. The problem thus resolves itself into a study of the transmission and fixation of the character of an individual plant to produce a given percentage of alkaloids, when grown under uniform and proper ecological conditions.

DEPARTMENTS OF BOTANY AND ANALYTICAL CHEMISTRY
ELI LILLY & COMPANY, INDIANAPOLIS

LABORATORY AND PLANT

AN INVESTIGATION OF THE EXPLOSION OF A SULFITE DIGESTER IN THE PAPER MILLS AT GRAND' MÈRE, QUEBEC[1]

By H. O. KEAY

The circumstances surrounding the disastrous explosion of one of the sulfite digesters in the paper mills of the Laurentide Company at Grand' Mère, Que., have presented a problem of no small interest, and it was with a view of determining so far as possible the causes leading up to this explosion that an investigation has been made, at the request of the Company, with the results set forth in this paper.

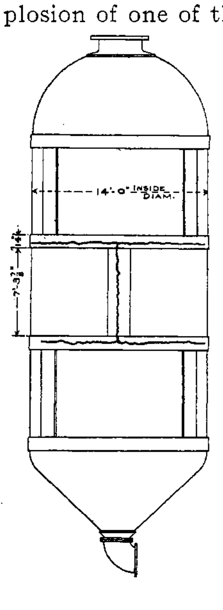


FIG. 1.

The rupture of the huge steel receptacle evidently started in one of the three vertical seams in the middle course, as indicated in Fig. 1. The sudden failure of the vertical seam was immediately followed by an opening out of the plates along the adjacent girth seams, until the upper and lower portions of the digester were completely separated.

The preliminary investigation immediately following the explosion failed to point conclusively to the cause of the trouble. Up to the time of the explosion, no signs of weakness in the digester were apparent. The Superintendent of the Sulfite Department had visited the digester house within the hour and found everything proceeding as usual. Charts recovered later showed no evidence of abnormal conditions, such as excessive pressure, sudden opening of the relief valve, or other action recognized as provocative of explosion in boilers. In the operation of these digesters, there is no appreciable amount of water hammer due to the introduction of steam at the bottom. The digester shells were protected on the inside by a lead lining, and a thorough inspection of the ruptured seams after the explosion revealed no pitting from acid to account for a failure from this cause.

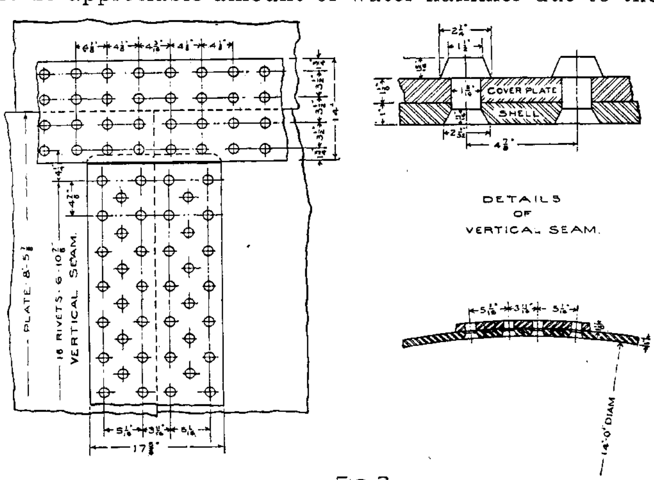


FIG. 2.

[1] We are indebted to Mr. Thomas J. Keenan, Editor of *Paper*, for this article which appears simultaneously in his Journal.

The usual calculations for direct stress on the seams of this digester (Fig. 2) do not indicate a stress likely to produce rupture.

Thus, where

P = internal pressure, taken as 100 lbs. per sq. inch, to cover the gauge pressure, the hydrostatic pressure of the contents, and any slight fluctuation above the normal.

r = inside radius of the digester shell = 84 inches.

t = thickness of the steel shell = 1 inch.

f = circumferential stress in the shell, in lbs. per sq. inch.

$$f = \frac{Pr}{t}$$

$$= \frac{100 \times 84}{1} = 8400 \text{ lbs. per sq. inch.}$$

and the longitudinal stress $= \frac{Pr}{2t} = 4200$ lbs. per sq. inch.

Taking a single pitch length of $4^7/_8$ inches on the vertical seam, the sectional area of the plates is reduced by rivet holes as follows:

Shell plate, $\frac{3.311}{4.875} = 0.6792$ of full pitch section.

Cover plate, $\frac{3.5625}{4.875} = 0.7308$ of full pitch section.

Hence the direct stress in tension in the vertical seam becomes for the shell plate, $\frac{8400}{0.6792} = 12{,}370$ lbs. per sq. inch, and for the cover plate ($1^1/_8$ inches thick), $\frac{8400}{1.125 \times 0.7308} = 10{,}220$ lbs. per sq. inch.

For the girth seam, by a similar process, the stress in tension is for the shell plate, 6750 lbs. per sq. inch, and for the cover plate, 5480 lbs. per sq. inch; hence the circumferential tension on the shell plate is the greatest, and assuming an ultimate tensile strength of plate 55,000 lbs. per sq. inch, the factor of safety in tension is $\frac{55{,}000}{12{,}370} = 4.45$.

Within the $4^7/_8$ inch pitch length, there are three rivet sections in single shear. Assuming a shearing strength of 45,000 lbs. per sq. inch in the rivets, the shearing resistance on one pitch becomes

$$\frac{3 \times 3.1416 \times 1.3125 \times 1.3125 \times 45{,}000}{4}$$

$$= 182{,}600 \text{ lbs.}$$

The load on one pitch is $8400 \times 4.875 = 40{,}950$ lbs., therefore, the factor of safety in shearing the rivets becomes $\frac{182{,}600}{40{,}950} = 4.46$, so the lower factor of safety is apparently that in tearing the plate between rivets, or 4.45.

Attention is now naturally directed toward the material of which the digester was constructed. For the purpose of forming an estimate of the suitability of this material, specimens were taken for chemical and physical tests, with the following results:

CHEMICAL ANALYSIS OF SHELL PLATES, DIGESTER NO. 3

Sample	Carbon Per cent	Sulfur Per cent	Phosphorus Per cent	Manganese Per cent
1	0.18	0.016	0.013	0.37
2	0.22	0.016	0.015	0.41
3	0.19	0.016	0.013	0.41
4	0.22	0.016	0.015	0.40
5	0.23	0.020	0.015	0.41
6	0.22	0.017	0.021	0.37
7	0.23	0.018	0.012	0.35
8	0.20	0.016	0.021	0.37
9	0.21	0.016	0.013	0.38

CHEMICAL ANALYSIS OF COVER PLATE, NO. 2 DIGESTER

	Per cent
Total carbon	0.313
Phosphorus	0.037
Manganese	0.420
Sulfur	0.020

Comparison with the specifications of the American Society for Testing Materials shows that the shell sheet falls within their recommendations, while the cover plate fulfils the specifications except in the matter of carbon, which is somewhat in excess—tending to give a harder and less ductile steel than is ordinarily used in boiler work.

Physical tests were made at the McGill University Laboratory, with the following results:

PHYSICAL TESTS OF MATERIAL FROM SHELL OF EXPLODED DIGESTER

Physical properties	Specimen 1	Specimen 2	Specimen 3
Ultimate strength. Lbs. per sq. inch	55,700	55,600	56,300
Elastic limit. Lbs. per sq. inch	10,700	16,200	16,900
Yield point. Lbs. per sq. inch	26,900	27,000	27,000
Elongation in 8 inches	28.8%	29.4%	32.6%
Reduction in area	57.9%	57.9%	58.4%
Modulus of elasticity	32,800,000	30,000,000	26,000,000

For comparison with the foregoing, the following tests were also made upon $1^1/_8$ inch steel recently furnished for similar purposes:

Physical properties	Specimen A	Specimen B
Ultimate strength. Lbs. per sq. inch	64,000	62,800
Elastic limit. Lbs. per sq. inch	15,000	13,700
Yield point. Lbs. per sq. inch	(a)	(a)
Elongation in 8 inches	31.1%	31.0%
Reduction in area	50.6%	53.0%
Modulus of elasticity	29,000,000	29,000,000

(a) No pronounced yield point, but a gradually increasing yield after the elastic limit was passed.

In both of the foregoing tests, the American Society for Testing Materials specifications are satisfied except for the yield point, which is low. The *elastic limit*, or limit of proportionality of stress to strain, however, is very low in both the old and the new material, ranging from 10,700 to 16,900 lbs. per sq. inch in the former, and from 13,700 to 15,000 lbs. per sq. inch in the latter. This characteristic of low elastic limit will be brought up later in the calculation of total stresses.

Subsequent investigations of the other vertical cover plates and of those removed from digesters of similar design and service revealed cracks starting between the rivet holes along the inner vertical row—precisely where failure occurred in the ruptured seam. The nature of the cracking is indicated in Fig. 3, which represents a piece of cover plate broken apart by blows from a sledge hammer. The shaded portion shows the location of cracks which had started near the rivet holes, largely on the inner side of the plate.

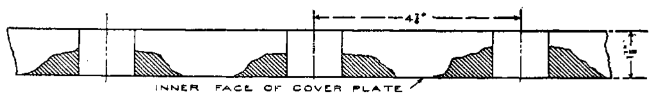


FIG. 3.

The general nature and location of these cracks pointed strongly to a failure by repeated bending of the cover plate under stress. While measurements on the inside of a similar digester showed a slight flattening of the curve near the seam, due probably to difficulty in the bending rolls, this peculiarity would prove rather a benefit than an injury, since the tendency of the cover plate is to take this formation under stress. The line of resistance in cylindrical shells under internal pressure tends to conform to the circle and since the single outside cover plate construction throws this line of resistance outside of the true circle, the tendency under stress is to restore it by bending the cover plate inward, as illustrated in Fig. 4.

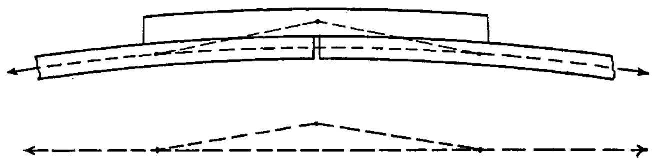
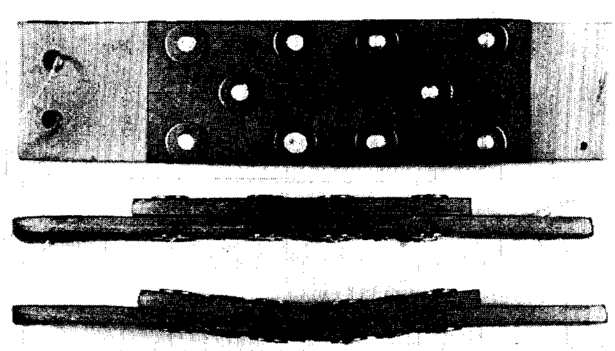


FIG. 4.

To exhibit this action more clearly, a one-fourth size rubber model of a section of this seam was made, as seen in Fig. 5. Fig. 6 shows a profile of the model before tension was applied, and Fig. 7 indicates clearly

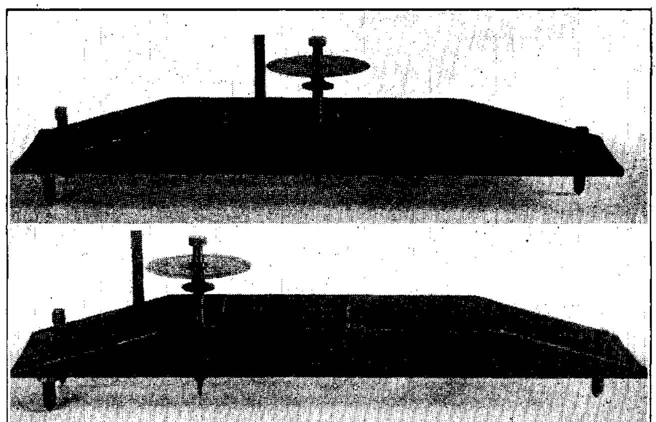


FIGS. 5, 6 and 7

the effect of tension on the seam. Particular attention is invited to the concentration of bending between the inner rows of rivets, corresponding in the full size seam to a span of about 3 inches.

This evidence naturally led to a desire to determine, if possible, the nature and extent of the inward deflection of the vertical cover plate under working conditions, and for this purpose a deflection gauge was devised, as shown in Fig. 8.

The frame of the instrument was made from a piece of 4-inch steel channel bar. The set screws constituting the legs are of hardened tool steel. The two at the left end are pointed, while the single one, at a distance of 17 inches from the first two, is slightly rounded. The pointed legs are forced into the cover plate near its outer edge, by light blows when the instrument is first in place, so that in subsequent readings it is necessary only to set the pointed legs back into

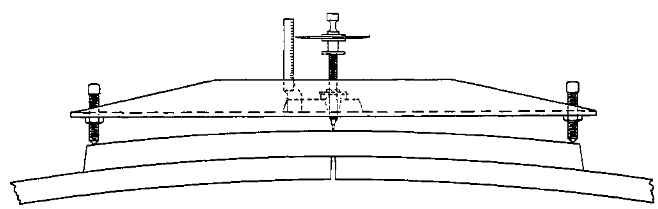


FIGS. 8 and 10.

these little depressions to insure an exact reproduction of the original setting.

The cover plate is polished where the single rounded screw-leg rests, as are also the spots where the micrometer measurements are made.

Fig. 9 indicates the method of application of the instrument for measurements of deflections at the center of the 17-inch span. The micrometer is firmly fixed in the center of the instrument frame for this setting, and in making observations, the micrometer screw is advanced until the sense of touch lightly indicates that its point rests upon the polished plate.



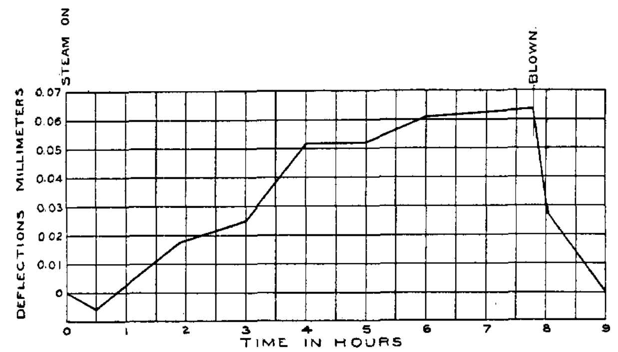
APPLICATION OF DEFLECTION GAUGE.

FIG. 9.

In exploring the curve formed by the deflections in the cover plate the micrometer was relocated at a point 4 inches off-center, as shown in Fig. 10.

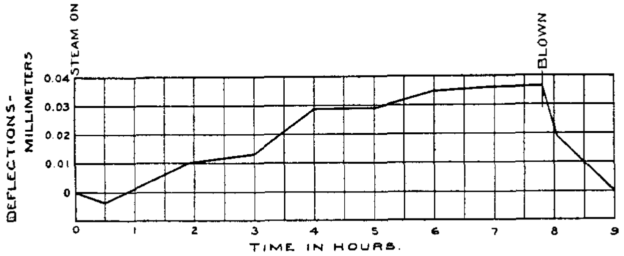
Measurements were taken at intervals ranging from thirty minutes to an hour, starting before the steam was turned on and continuing for at least half an hour after the digester was blown. The diagram, Fig. 11, which is typical, presents a graphical record, on a time base, of the deflections observed at the center of the 17-inch span, while that of Fig. 12 is for a point 4 inches off-center.

The maximum deflections obtained in the tests represented by Figs. 11 and 12 are replotted on the diagram in Fig. 13, on a base line representing the 17-inch span. The ordinates at the center and at points 4 inches off-center are plotted to a magnified scale and the smooth curve drawn through these points shows the nature of the deflection. As forecast roughly in the behavior of the rubber model, the concentration of bending is almost exactly over a span of 3 inches in the middle portion. The deflection at the center of the 3-inch span is found to be 0.0003 inch.



INWARD DEFLECTION OF VERTICAL COVER PLATE—CENTER OF 17 INCH SPAN

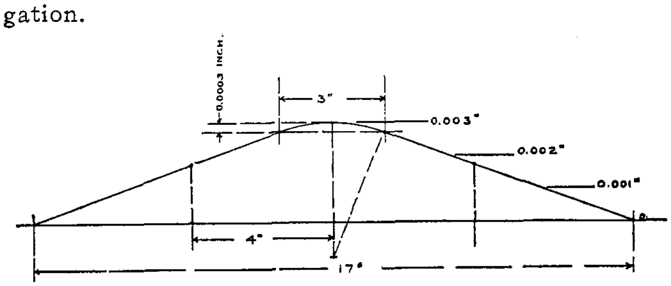
FIG. 11.



INWARD DEFLECTION OF VERTICAL COVER PLATE—AT POINT 4 INCHES OFF CENTER

FIG. 12.

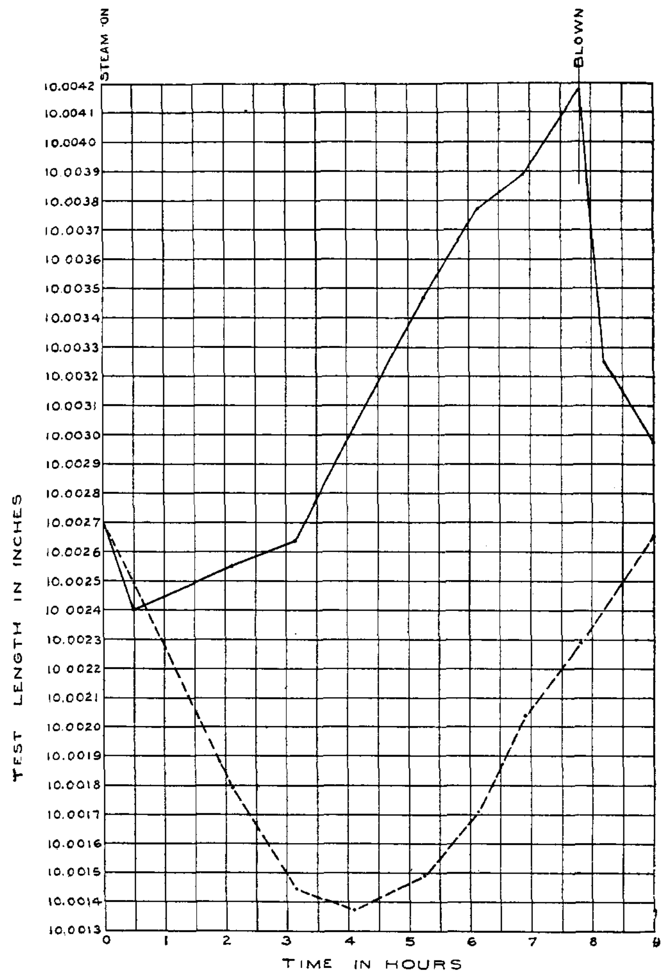
Just why the cover plate should persist in bulging out slightly immediately after the steam was turned on the digester, following the recharge, as shown by the negative deflection in both diagrams, was at first a troublesome question, and called for further investigation.



MAXIMUM INWARD DEFLECTION OF COVER PLATE.

FIG. 13.

Since these deflections were assumed to be the result of circumferential stress in the shell, it seemed reasonable to suppose that if some sort of extension gauge were applied to the shell sheet in this region, the corresponding stress could be readily calculated. For this purpose, a Howard strain gauge was applied at the same height on the digester as the deflection gauge, and midway between the vertical seams of the adjacent sheet. This strain gauge is in reality a special micrometer capable of indicating within 0.0001 inch error any change in length between two small carefully prepared holes drilled 10 inches apart. Where the modulus of elasticity of steel is 30,000,000, an extension of 0.0001 inch represents a tensile stress of 300 lbs. per sq. inch. This test length was taken along the circumference, and readings were made simultaneously with those of the deflection gauge, together with the shell temperatures obtained from a thermometer sealed to the shell sheet. The results of these readings are shown in full lines on the diagram, Fig. 14, while the dotted lines indicate how this test length would have varied under the influence of temperature alone. It was, of course, prevented from so varying by the internal pressure, therefore the distance measured up from the dotted line to the full line gives the extensions due to internal pressure.



- STRAIN GAUGE READINGS SHOWN IN FULL LINES
- CHANGES IN 10-INCH TEST LENGTH ON SHELL DUE TO TEMPERATURE SHOWN DOTTED

FIG. 14.

To exhibit more clearly what is going on during a single cook in the digester, a combination diagram, Fig. 15, has been plotted with diagrams A, B, C, and D on the same time base.

Diagram A gives a graphical record of the temperatures inside the digester, the shell temperatures, and the temperatures at a point in the middle of the brick lining. The latter were obtained by drilling a small hole through the shell and half way through the lining. Into this hole a thermometer was inserted and carefully packed with fiber to isolate the bulb from outside conditions. An important feature of this diagram is the fall in temperature of the middle of the lining and of the shell after the steam was turned on, continuing for two or three hours, and finally rising again. This is due to the chill of the recharge and the slow transference of heat in the brick and cement lining.

Diagram B is plotted from the pressure chart, and the figures at the left show the pressures in pounds per square inch during the cook, while the figures at the right show the corresponding calculated stress in the shell, and the maximum stress—between rivet holes—in the cover plate, respectively.

On diagram C the full line indicates the stretch in the 10-inch test length calculated from the pressure

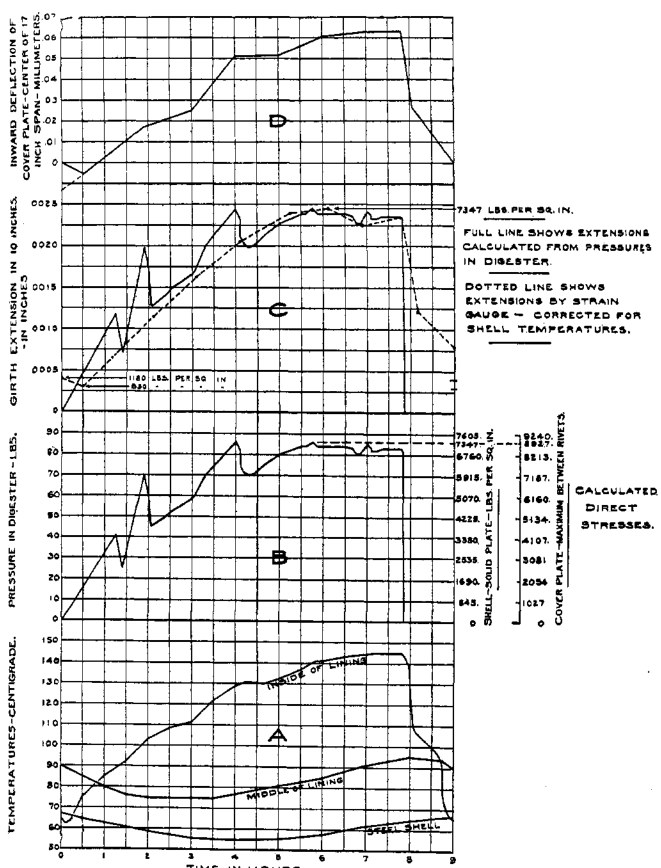
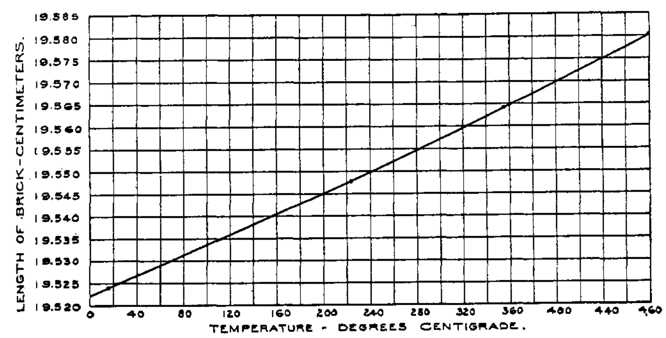


Fig. 15.

in diagram B, while the dotted line shows the stretch in this test length obtained from the strain gauge readings, corrected for shell temperatures as explained in connection with Fig. 14. The maxima of the two curves are placed as nearly coincident as possible in order to show how nearly back to zero the dotted line will come; in other words, how nearly back to rest the shell plate will come, at the beginning of the cook. It will be noted that there appears to be 1180 lbs. per sq. inch residual stress in the shell sheet at the time when the steam was turned on, falling to 850 lbs. per sq. inch half an hour later and then rising slowly to the maximum.

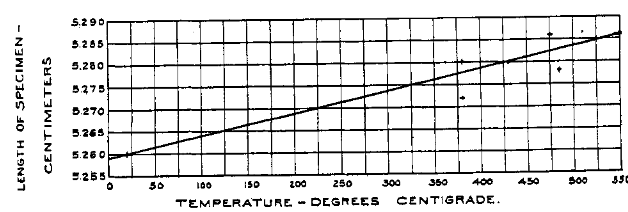
For convenience of comparison, diagram D, showing the corresponding deflections at the center of the cover plate, is plotted immediately above C. It is at once noticed that the cover plate began its inward deflection exactly half an hour after the steam was turned on *and simultaneously with the beginning of stretch in the shell*, shown dotted in diagram C.

Thus far we had established the relation in action between the girth tension in the shell and the inward deflection of the cover plates, but the reason why the stress relaxed for a short time, or for any time at all, after the steam had been turned on the digester, had not been explained. It was felt that in some way the expansion of the brick lining had something to do with the case, and it had even been suggested that this expansion may have been able to produce an excessive stress upon the seam. That the latter assumption is incorrect is shown, first by the fact that the strain gauge did not indicate a greater stretch in the shell than would be expected from the internal pressure; and again, from the following separate investigations



THERMAL EXPANSION OF DIGESTER BRICK

Fig. 16.



THERMAL EXPANSION OF DIGESTER LINING CEMENT.

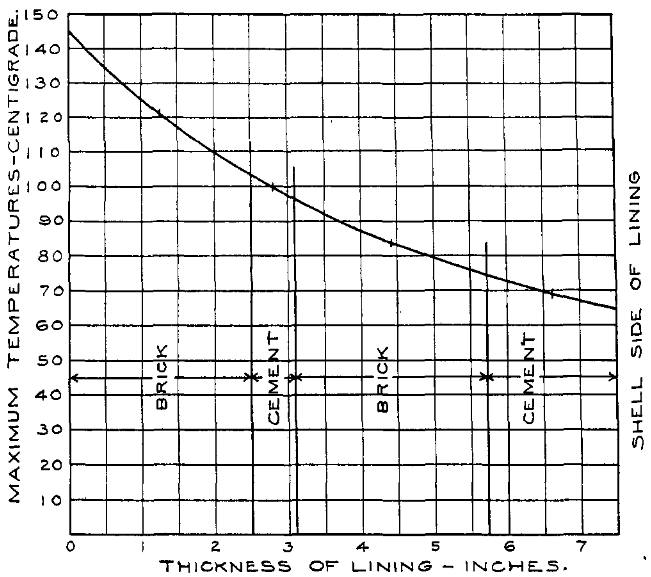
Fig. 17.

of the characteristics of the brick and cement of the lining:

A sample of the brick similar to that used in the lining of this digester was selected for determining its thermal expansion. This brick was polished at points on its ends, and slowly heated in a gas furnace in contact with the thermo-junction of a LeChatelier pyrometer, and its length measured every few hours with a delicate micrometer. The result of this experiment is shown graphically in Fig. 16. Similar tests were applied to a cube of lining cement, with results as shown in Fig. 17. From these, the coefficient of thermal expansion of the brick was found to be 0.00000608, and of the cement, 0.00000927 per degree Centigrade.

From diagram A of Fig. 15, the maximum temperatures attained by the inside and middle of the lining, and by the steel shell were replotted in Fig. 18 on a base to represent the thickness of the digester wall, and a smooth curve drawn to show the fall in temperature from the inside to the outside of the digester.

The mean temperature of each layer of the lining, taken from Fig. 18, was now utilized to determine



APPROXIMATE MAXIMUM-TEMPERATURES IN DIGESTER LINING.

FIG. 18

the amount of expansion in each case for the entire circumference—assuming the layers free. The results of this calculation are given in the last column of Fig. 19 under the heading "Free Extension."

It will be noticed that the circumference of the shell will extend 0.25 inch during the cook, while the average extension of the inner two layers of the lining would

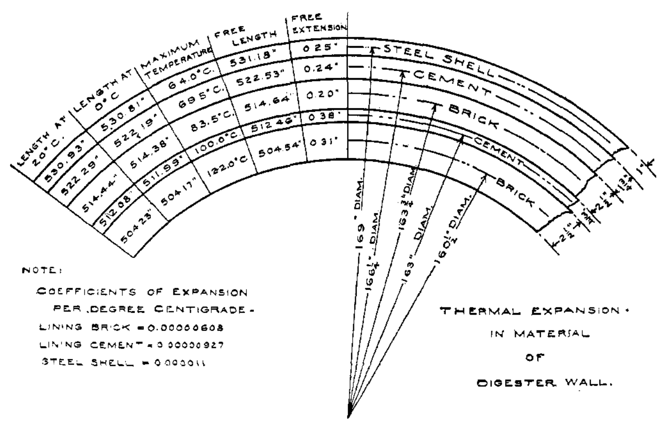


FIG. 19

be 0.34 inch, if allowed to expand freely. At the most, this would give a difference of 0.09 inch to be accommodated between shell and lining in the entire circumference of the digester. It can be readily shown that this has no effect, since if the shell extends 0.0024 inch in 10 inches, due to internal pressure (see diagram D, Fig. 15), then in the circumference of the digester there would be a total extension due to pressure alone = (531 × 0.0024) ÷ 10 = 0.127 inch, which lifts the shell clear of any possible crowding by the lining while the pressure is on.

When the digester is blown, however, the removal of internal pressure causes the shell to contract, and it therefore settles back upon the lining, which at this time is expanded to its maximum by heat. Diagram A, Fig. 15, shows the temperature of the middle of the lining to be *decreasing* after the steam has been turned on, with consequent contraction, so the shell now follows the lining back until internal pressure again lifts the plate away from the lining. This accounts for the curious action of the shell and cover plate for the brief period at the beginning of the cook.

Where the shell is shrinking back upon the lining, the latter would be expected to compress more than the former to stretch for a given force, and it was with a view of determining the exact relation that the moduli of elasticity of both brick and cement were obtained from compression tests at the McGill University Laboratory. Results of these tests are shown in the following table:

Physical properties	Brick	Cement
Ultimate compressive strength. Lbs. per sq. in...	8,770	4,800
Modulus of elasticity..........................	3,080,000	1,150,000
Length taken for extensometer.................	4 inches	1.4 inches

Thus the modulus of elasticity of the steel is about ten times that of the brick lining; in other words, a given section of brick would compress ten times as much as an equal section of the shell would stretch, within the elastic limit of the weaker material.

TOTAL STRESS

Proceeding now to the calculation of maximum stress in the cover plate, it will be recalled from the diagram, Fig. 13, that the maximum deflection at the center of a 3-inch span was found to be 0.0003 inch. Making use of the general formula for the deflection of beams of uniform section, within the limits of proportionality of stress to strain,

$$d = \frac{A\bar{x}}{EI}$$

where

d = distance from a point on the beam to any tangent.
L = length of tangent thus included.
A = area of bending moment diagram.
$\bar{x}$ = distance from chosen point to center of gravity of bending moment diagram.
E = modulus of elasticity of material.
I = moment of inertia of beam section about neutral axis.
M = bending moment (uniform in this case).
f = extreme fiber stress.
y = distance from neutral axis to extreme fiber.

$$A = ML, \text{ and } \bar{x} = \frac{L}{2}$$

$$d = \frac{A\bar{x}}{EI} = ML \times \frac{L}{2} \times \frac{1}{EI} = \frac{ML^2}{2EI}$$

$$M = \frac{2EId}{L^2}$$

$$\text{but } f = \frac{My}{I} = \frac{2EIdy}{L^2 I} = \frac{2\,Edy}{L^2}$$

substituting, $d = 0.0003$
$L = 1.5$
$E = 30,000,000$
$y = 0.5625$

$$f = \frac{2 \times 30,000,000 \times 0.0003 \times 0.5625}{1.5 \times 1.5}$$

= 4500 lbs. per sq. inch, due to bending.

Adding to this the maximum direct stress in the cover plate, 4500 + 10,220 = 14,720 lbs. per sq. inch, the maximum repeated stress on the inner side of the cover plate.

Reverting to the results of tensile stress on material from the shell of this digester, and from new material used for similar purposes, it will be recalled that the true elastic limits were shown to range from 10,700

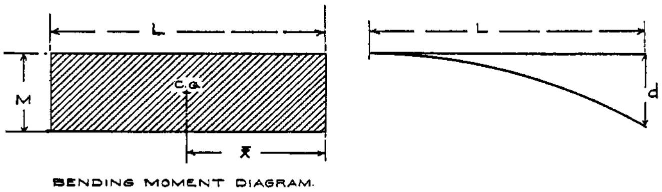


FIG. 20.

to 16,900 lbs. per sq. inch. Since the true elastic limit, rather than the ultimate strength, is a vital consideration in repeated stresses such as we are dealing with here, the fact that the maximum fiber stress of 14,720 lbs. per sq. inch falls within the range of elastic limit of the material is most significant. No steel will endure for an unlimited period a repeated stress even slightly above its elastic limit. In this case it took fourteen years of repetition of the stress to cause rupture, but the same action is present in all digesters of similar design—the stress varying in magnitude with the thickness of the cover plate and the pressures carried. Where this stress is shown to exceed the elastic limit of the material of the cover plate to any extent whatever, ultimate failure from repeated bending must be expected.

McGill University
Montreal, Canada

GERMAN OBSERVATIONS ON OUR INDUSTRIES

WHAT DID WE CHEMISTS LEARN IN AMERICA?[1]

By B. Rassow

"He who would understand the poet must go to the poet's country." ("Wer den Dichter will verstehen, muss in Dichters Lande gehen!") These words of Goethe are applicable not only to the appreciation of the poets of a foreign country, but also to the general comprehension of its inhabitants and more particularly of its industrial life.

It is said of us Germans, that we have in us a special nomadic impulse. Doubtless this impulse to travel is traceable not only to esthetic motives, but also to our craving to learn how other peoples think and work. That our own science and technique are greatly advanced thereby is a matter of course.

Of all industrial countries, there is no doubt that the United States of America are at present of the greatest interest to us Germans. The conditions under which technical work and manufacturing are carried on in North America are, in some respects, very similar to our own, but in others, very different from them.

It is hardly possible to imagine a greater difference, than we find between the activity of the German manufacturer, who can hardly move, in our old and densely populated country, without being hampered by police ordinances and by the rights of his neighbors—who is forced by the state to care for his employees on a large scale, even in times during which the employee is of no further use to him—and, on the other hand, the American manufacturer, unrestricted by all such considerations and fetters.

But the great similarity between American industry and our own is doubtless caused, in part, by the fact that our industry is in reality just as young as that of the United States. The modest beginnings of factories, which came into existence in some of the German states 200 years ago or more, are only insignificant germs of the mighty development of German industry, which has really been established for only about 100 years.

The beginnings of American industry also date back about 100 years, *i. e.*, to the time when the United States became politically and commercially independent, when manufactured goods were no longer procured exclusively from the English mother country, and home manufacture was begun instead. There, then, as with us, we see in the last century the conversion of an agrarian state into a political organism, in which, until a few years ago, agriculture and industry still possessed about equal importance for the entire political economy, while at present the conditions are continually becoming more favorable to industry.

[1] Address delivered at the Annual Meeting of the Verein Deutscher Chemiker, Breslau, Sept. 18, 1913. Translated by The Chemists' Club Library from *Zeitschrift fuer angewandte Chemie, Aufsatzteil,* **26**, 1913, p. 705.

Many of us German chemists, when preparing for the journey to North America a year ago, hardly realized these reasons for the special interest which every German must feel towards the United States and her industry. Doubtless, however, the great longing which drives progressive German scientists and technologists to the United States, is traceable to this line of reasoning. But I should like to refer at the very beginning to one essential difference. Germany is a country having a civilization many centuries old, which, up to the middle of the 19th century had, it is true, manifested itself essentially in literary and esthetic spheres. It is quite otherwise with America. There, the beginnings of civilization do not extend back much more than two centuries. During the last century the majority of the immigrants were poorly educated workmen—men who lacked all literary and scientific training and all advanced technical knowledge. Therefore we cannot be surprised that, in many sections of the Union, in spite of wealth, a finer appreciation of culture appears only in the second or third generation.

We chemists made the journey across the ocean principally on account of the Eighth International Congress of 1912. Though we are accustomed to seeing Germany well represented in the international chemical congresses, this was especially the case at the Eighth International Congress. A good half of the non-American participants in the Congress came from Germany. The reason for this is naturally to be found as much in the magnificent development of the German chemical science and industry, as in the German impulse for study and travel. To be sure, we know that several of the European countries, *e. g.*, England, are still ahead of us in many branches of the chemical industry, especially in inorganic manufacture. But in no country on earth are those branches of the chemical industry which demand versatility of thought, and particularly a large body of scientifically trained employees, so well developed as with us. Our synthetic dye, synthetic drug, and perfumery industries are foremost throughout the world, and there is probably no country in which the heads of factories are so imbued with the conviction that their employees must needs cast a glance beyond domestic boundaries. That our government authorities willingly aid its employees in the study of foreign institutions, is well known. Accordingly, we counted among the German participants in the Congress no small number of professors of chemistry and technology and appointees of various national government bureaus.

But those colleagues whom we met there were also largely of German extraction, or had studied in Germany. Thus it